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A Comparison of Isometric Exercises and Weight Training on the Development of Leg Strength and Jumping Ability in Secondary School Boys

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A COMPARISON OF ISOMETRIC EXERCISES AND WEIGHT TRAINING ON THE DEVELOPMENT OF LEG STRENGTH AND JUMPING ABILITY IN SECONDARY SCHOOL BOYS

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

In the last few years isometric training has been popularized and this method appears to be replacing weight training pre-season and during the season of varsity athletics. The majority of the claims made by the proponents of each of the two methods have been based upon experimental evidence which has been presented to support the contentions of either side. Therefore, their methods warrant a comparative study.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to determine the respective effectiveness of isometric and isotonic training in the development of leg strength; (2) to show the relationship of each of the two methods in leg strength development; (3) to investigate the improvement of jumping ability, as revealed through an experimental study; and (4) to compare both methods with the physical education exercises used at Davis High School.

Importance of the study. One of the main determining factors in an individual's ability to compete and endure competition in varsity athletics is the functioning

of the legs. Therefore it is of the utmost importance to develop the legs in order to get maximum strength, explosive power, endurance, and to increase jumping and running performance. Since there is a difference of opinion as to which procedure is the most effective in developing the legs and maintaining the effectiveness during the season, there is a definite need for a comparative study of isometric exercises and isotonic training.

II. DEFINITIONS OF TERMS USED

Isometric exercise. Throughout this study the term isometric exercise will be defined as exercise without motion or as the attempt to move an immoveable object. The term isometric contraction is derived from the fact that during exercise there is no change in the length of the muscle. Iso means same, metric means length. Although no work is done, near maximum effort is extended.

Isotonic training. Isotonic training is a routine of exercises performed with bar bells, using 15 repetitions as one set. The exercises are designed to develop the legs.

Isotonic contraction. When the resistance offered by the load is less than the tension developed, the muscle shortens and performs mechanical work; thus defined, isotonic contraction means to exercise with motion.

Leg strength development. Leg strength development refers to the ability of the muscles used in planter flexion in the leg to grow in strength.

Endurance. Endurance is the ability of muscles to sustain prolonged activity.

Dynamometer. The Dynamometer is an apparatus for testing muscular strength of the legs.

Sargent jump. The sargent jump is a method of testing vertical jumping ability as described by Clarke (16:272).

Set. A set is fifteen repetitions of isotonic exercise and one ten second isometric contraction.

Military press. The bar is raised to the chest, standing with the feet the width of the shoulders, one foot a few inches in advance to aid balance. The bar is then moved above the head until the arms are straight. The bar is then lowered to the chest and the remainder of the repetitions are done in the same fashion.

Squat jump. The squat jump is a thigh and calf exercise

using weight on the back. The subject starts with the feet the width of the shoulders, one foot eight to ten inches in front, back is straight, and the thighs are parallel to the floor. The subject then takes a deep breath, holds it and jumps for height. On the way down feet change positions. The subject exhales while returning to squat position. Continue the repetitions.

Toe rise. The subject stands holding weight, in back of the head, and with both feet spread the width of the shoulders, legs straight, and his toes on a three foot long, two by four board. He then raises up on his toes as high as his body will allow, and then lowers his heels to the floor. The subject then repeats this a total of fifteen times.

Sit ups. The subject lies supine with the feet hooked under the bleacher, knees bent, clasps hands behind the head, then curls the head up next to the shoulders, followed by the trunk bending over and touching the elbows to the knees.

Side straddle hop. The subject stands erect, hands at side, and feet together. The hands move above the head with the arms straight; at the same time the feet hop to the width of the shoulders. The hands and arms are then brought back to the side of the body and the feet are brought back together.

Burpee. The subject stands erect, then bends at the waist, the hands touching the floor and the feet kicking out

backwards. The body is now in a leaning rest position. The knees are brought back under the hips and the individual stands up to the original position.

Push up. The subject's body is in a leaning rest position to start. The back is straight and the head is up. The arms let the body down so only the chin is touching. The arms are extended and the body is raised to a leaning rest position once again.

Horse back relay. Two individuals are in a piggy back position. They run the length of the gymnasium, there they exchange positions and return.

Firemans carry relay. Two individuals, with one across the others shoulders in a fireman's carry position. They run the length of the gymnasium; there they exchange position and return.

Leap frog relay. Two individuals with one down on his hands and feet while the other jumps him and maintains the hands and feet position. They alternate positions the length of the gymnasium and back.

Dog relay. The individual takes a hands and feet position on the floor, similar to that of a dog, and runs, palms touching, the length of the gymnasium.

Backward crab relay. The individual sits down and places hands and feet on the floor, while alternating hands and feet he moves backward down the floor to the end of the gymnasium and back.

III. SCOPE OF STUDY AND LIMITATIONS

The study was limited to 120 fifteen-year-old sophomore high school boys who participated in regular physical education classes that met five times a week. This study was limited to three days a week of experimental exercises. The experiment was limited to two isotonic exercises and two isometric exercises. The isotonic exercises used were the squat jump and toe raises. The isometric exercises were comparable to the isotonic exercises but used on an improvised isometric board.

Since it was desirable for the final results to apply to a normal class situation, the counselors of Davis High School Administration selected the subjects randomly from three hundred and sixteen sophomores. These subjects were then placed in class periods one, three, and four.

The author attempted, both during testing and during the exercising periods, to motivate the subjects to perform at their maximum potential. No attempt was made to measure the effectiveness of the motivation.

CHAPTER II

PROCEDURE

I. PRELIMINARY STEPS

The entire experiment--pre-tests, second test, and final test and the program--was carried out over a nine-week period. Previous to the beginning of this nine-week period of testing and exercising, several preliminary steps were carried out. Unit plans for the isometric, isotonic, and physical education exercises were developed. The main program exercises used for the isometric phase were limited to two developed by the author, the squat and the toe rise. The exercises for the weight training were the squat jump and toe raises which were selected from the Davis High School basketball weight training program.

The dynamometer and Sargent Jump Test were used in determining leg strength development and jumping ability. These tests were selected due to the high reliability and validity of both tests.

II. SUBJECTS

One hundred twenty subjects, fifteen years of age, were used in this study. The isotonic training group consisted of forty subjects; the isometric exercise group

consisted of forty subjects; and the physical education group, or control group, had forty subjects. The subjects were enrolled in three sophomore boys' physical education classes in September, 1964.

The first day an explanation of the experimental program was given to the groups and a grade was given on the amount they improved. This was used as a means to stimulate motivation. The second day began the testing of the dynamometer and the Sargent Jump. The third day a re-test of the Sargent Jump was given. The fourth day a test was administered to the isotonic group for homogeneous grouping purposes.

III. TESTS

The following criteria were used to select the tests: (1) Significant validity and reliability of testing equipment; (2) Ease of administration; (3) Measurement of the leg strength development; (4) Measurement of jumping ability; and (5) The availability of a measuring device.

Pre-test on weights. A pre-test was administered to the weight training class to determine homogeneous groups.

Berger's study reveals that groups that are homogeneous in strength can be formed initially in weight training classes on the basis of the military press (9:515). This was to eliminate the wasting of class time.

The pre-test was conducted with five sets of bar bells set at 50, 60, 70, 80 and 90 pounds each set. The subjects tried to press the weight, according to their size and physical structure, nine times. The number of repetitions the subject was able to do put him into a group above or below the amount he attempted and thus they were divided into three groups, 60 pounds, 70 pounds, and 80 pounds. Each group varied from one another in terms of strength. By the end of nine weeks these groups advanced to 100, 110, and 120 pounds.

The isometric exercises were done by squads which were selected homogeneously as to body height. The regular physical education classes were divided by random selection into six squads.

Dynamometer test. The leg strength development test was developed by Rogers and tested by a dynamometer. The subject held the bar with both hands together in the center with the palms down at the junction of the thighs and trunk. The feet were parallel, six inches apart, center of feet opposite the chain, legs bent at 115 to 124 degrees, arm and back straight. The test administrator placed the looped end of the belt over the end of the cross bar. The test administrator looped the free end of the belt over the opposite end of the cross bar, tucking the free end under

the belt where it crosses the hips. The subject was in position for the pull or leg lift, although the arms were straight. The subject pulled, and the dial pointed to the amount of leg lift. The figure was recorded. The administrator must be sure that the arms and back are straight, head erect, and chest up on the leg lift. The subject must straighten the legs to lift (4:93).

The vertical jump test. The Sargent Jump Test has been proven valid by Sargent, and McCloy substantiated this with a restudy. McCloy found a test reliability of .98 was obtained when the best jump from a series of three jumps each (on two different days) was correlated against the best from two other series of three jumps each (also done on two different days) and corrected for attenuation. The VJ is the best single measure of "jump power" available although McCloy has indicated that the standing broad jump, when well learned, equals it for this purpose (1:42-43).

The validity of this jump is further substantiated by McCloy and by Coleman. It is generally agreed by experimentors that the best results are obtained with this test after the technique of the jump has been taught, and the subjects have practiced its execution. Under the conditions, reliability coefficients have been reported at .85 and .96 (16:274).

In the jump, the individual swings his arms downward and backward, taking a crouch position with knees bent approximately to a right angle (115 degree angle was used). The subject pauses in this position to eliminate the possibility of a double jump, and leaps upward as high as possible, swinging the arms forcefully forward and upward. Just before the highest point of the jump is reached, the arms should be swinging forward and downward, motion being timed to coincide with the height of the jump. The specific arm movements in executing the jump are extremely important, the test developing serious inaccuracies without them (11:273).

Prior to the pre-test, the subjects were instructed five minutes each day for a period of two weeks in jumping. The best of three jumps were taken from a series taken on two different days.

Pre-test. A pre-test was given with the dynamometer to measure the leg strength development, and the Sargent Test was given to measure jumping ability.

Second test. The second test was given the same as the pre-test at the end of five weeks.

Final test. The final test was also given by the same methods as the pre-test at the end of nine weeks.

IV. EXERCISES

Weight exercises. In performing the squat jump, the subject stood with the hands on the weight bar in back of the head, and the right foot about eight to ten inches in front of the left foot. He squated down until his thighs were parallel with the floor. He then jumped upward until both lower legs were completely extended, and the feet had cleared the floor. Then he squated down as before and again jumped into the air, and these movements were repeated fifteen times.

The second exercise performed in the weight training program was toe raises. The subject stood holding weight, in back of the head, and with both feet spread the width of the shoulders, legs straight, and his toes on a two by four board three feet long. He then raised up on his toes as high as his body would allow, and then lowered his heels to the floor. The subject then repeated this a total of fifteen times.

Isometric exercises. The first isometric exercise performed was the squats. The subject would squat down on the isometric board and adjust the bar after taking a position where the knees were parallel to the floor. After the bar was adjusted to the shoulders, the subject exerted maximum strength upward against the bar for a ten second period.

The second isometric exercise was toe raises. The subject stood erect with the bar adjusted across the shoulders and a four foot long, two by four board placed under the toes. The subject exerted maximum effort upward for a period of ten seconds.

Physical Education exercises. The forty subjects in this group took part in ten minutes of calisthenics which included push-ups, sit-ups, burpees, side straddle hops, and squat jumps. The group also had several relays which were horse back, fireman's carry, leap frog, dog, and backward crab.

The isometric and isotonic exercises were conducted Monday, Wednesday, and Friday for nine weeks. The physical education exercises were conducted daily for a period of nine weeks. After the weight training, isometric and regular classes finished their exercises, they participated in American football, a game which resembles touch football, for the remainder of the period.

CHAPTER III

REVIEW OF LITERATURE

I. HISTORY OF WEIGHT TRAINING

The popularity of weight training as a means of body building and in season conditioner is relatively recent. Weight lifting on the other hand dates back to the early Olympic games.

The earliest weight lifter of note was the great Greek wrestler, Milo of Croton, who won fame in ancient Olympic games (30:3).

In preparation for weight lifting contests Milo used the gradual progression from a light weight to heavy poundage. "This is the same one followed today to develop strength and improve physical condition by exercising with adjustable bar bells and dumbbells (30:3)." However, in addition to adjustable bar bells and dumbbells, there are now weight machines which do not require adjusting of weights thereby speeding up work outs and aids in the safety of the lifter. "The weights lifted in the early days were solid, clumsy and very heavy. A man had to be extremely strong to get into weight lifting because of the non-adjustable weights (30:5)."

In the middle European countries weight lifting, as we know it today, got its start in carnivals and vaudeville.

Joseph Steinbauch and Karl Swoboda were a couple of early German weight lifters who were known for their brute strength. They ranged from two hundred fifty to three hundred pounds and had large waist lines to match their massive arms and legs (30:6).

There is little mention of the sport of weight lifting in the United States prior to 1850 although it is known that the colonists used dumbbells for exercising. Benjamin Franklin once wrote in a letter to his son "that exercising with dumbbells was once a method of obtaining better health (13:9)." Arthur Saxon, 1905, was another great German strongman; although not a huge man at two hundred ten pounds, he had the distinction of having lifted more weight overhead under control than anyone except Paul Anderson, the famous twentieth century American weight lifter (30:6).

Most of the interest in weight lifting in the United States came through immigrants from central Europe and Germany during the nineteenth century. From 1850 to 1900 interest was added through growing number of professional strongmen from other countries (13:10-11). Strongmen gave performances in carnivals, vaudeville, and in back rooms of taverns.

George Hackenschmidtz held the world record for the one hand snatch with 197 1/2 pounds. In 1930 a French

lifter improved it to 256 1/2 pounds. He was also the first man to clean and jerk 400 pounds (30:3).

Harry Poschall was an early American weight lifter and later writer in the field of weight lifting (20:10). As weightlifting increased mail order, supply companies, and magazines added to its popularity.

Alan Calvert established the Milo Barbell Company in 1903. Clavert was a truly inspirational writer in his book, Super Strength, now a collector's item, and in a small magazine he published called, Strength (31:12).

The public followed weight training of outstanding athletes as Bob Richards, Parry O'Brien, Fortune Gordien, Dick Cleveland, Jack Kelly Jr., Henry Wittenberg, and Frank Stranahan (20:23). Dr. Charles McCloy, late professor of physical education at the state university of Iowa, believed the weight training at home is its most valuable application. McCloy favored teaching of weight training in schools and colleges because of its lifetime carry-over value. McCloy contrasted this with other means of exercise, such as tennis, wrestling, and basketball (31:24).

From here weight lifting and weight training parted company. Weight training, as considered in this treatise refers to a systematic, well-balanced program of exercises in which the participants use weight, bar bells, and dumbbells to increase the resistance of various bodily

movements. This type of exercise is contrasted with the competitive type usually referred to as "weight lifting". In weight lifting the competitors endeavor to raise a maximum weight in a single lift, whereas in weight training the participant executes many consecutive repetitions of each exercise with a weight which has been found to be compatible with his strength and endurance (14:188).

In this manner the "overload principle" was developed. The amount of tension a muscle must exert to overcome a resistance is the key to muscular development. A muscle which contracts against a resistance that demands exertion increases in strength. If the muscle is strengthened enough to overcome resistance easily, then that resistance is no longer exerting the muscle and there is little if any gain in strength. In order for the muscle to make further gains, the amount of resistance must be increased. This is known as the overload principle.

Basically, three methods or systems are currently in use for the development of strength. The first and most widely used of these is DeLorme's progressive resistance exercise. This system consists of determining the maximum resistance which can be overcome for ten repetitions. The second method, infrequently used, was first described by Zinovieff of England. That system is known as the Oxford technique. In this exercise program, maximal resistance is

introduced at the onset of exercise and then reduced systematically until the onset of fatigue. As can be seen, it is essentially the reverse of the procedures of DeLorme. The third and more recently described procedure, developed by Hettinger and Muller of Germany is called isometric contraction. Isometric contraction, neither new nor revolutionary, has only recently been applied to a wide variety of sports (26:7-8).

II. HISTORY OF ISOMETRIC TRAINING

It was believed for many years that the only valid method of developing muscle strength was repetitive dynamic exercising against an overload for an extended period of time. In recent years the theory of isometric contraction has been introduced which challenged this idea.

Isometric contraction or IC is any kind of exercise in which the muscles strain and tense against an immovable object or each other for a few seconds without movement (32:19).

Actually IC has been around since the early 1920s when scientists tied down one leg of a frog and found that in straining against its bonds, the tied-down leg grew stronger (29:78). Physical therapists were using some forms of isometric contraction to strengthen muscles of limbs in casts in the '20s (19:59).

In 1921 Charles Atlas, brawny patron of the 97 pound weakling, began preaching the muscle building system he called dynamic tension, which pits one muscle against another (2:47).

Increased interest in the type and intensity of exercise which produces greater strength gains resulted from investigations of two German researchers, Muller and Hettinger, in 1953. They reported an increase in strength of 5% of the initial strength per week as a result of various short duration contractions (26:27).

Muller attempted to find how strong, how long, and how often a stimulus must operate to get an increase in strength (23:10).

Arthur H. Steinhaus, formerly of George Williams College, one of the most respected voices in the field of physiology, translated the reports to English. Steinhaus and other physiologists, of course, realized that isometrics had a place in physical fitness programs. Their voices were drowned out by the groundswell of public interest in this new instant exercise that promised fitness without fuss or sweaty exercise. It was like Clark Kent stepping into a phone booth and emerging as Superman. Nobody has produced a pill that you can gulp with a glass of water and become physically fit, but until one comes along isometric will do (19:66).

Many others followed Muller such as Rarick, Sarsen, Wolbers and Sills, Hansen, Henry, and Whitley.

Their studies indicated that an increase in muscular strength will result from static contraction and that daily periods of static contraction held briefly at half maximal power were the most effective in strength development. It was also found that static strength was not a good measure of strength in movement activities (23:11-12). Little had been heard about isometric contraction until the news of the Pittsburg Pirates' "secret" training routine got out. The secret (SI, July 24, 1961) was that the pirates had introduced IC to their players under the direction of Jay A. Bender, Ph.D., professor of physical education at Southern Illinois University (32:19). Bender also worked with the San Francisco Forty-niners even before the Packers discovered isometrics, although the Forty-niners may have benefited in terms of muscular fitness, they never had Hornung or Taylor (19:58).

Louisiana State University and Notre Dame were the first major college teams to use isometric contraction extensively in their conditioning programs.

Coach Red Hickey of the San Francisco Forty-niners admitted that his shotgunning team used IC but refused to talk about it, evidently considering it a secret weapon. Another strong IC booster is Bob Hoffman the messianic Olympic weight-lifting coach, "It's the greatest thing the world's ever seen (32:20)."

Lou Riecke, for example was lifting weights for fourteen years with little success. In November of 1960 he stopped weight training and began a set of isometric exercises for a mere fifteen minutes a day including rest periods. At the end of six months, he was able to press 300 pounds, forty-five more than his previous high. He could snatch 305 instead of 265, and clean-and-jerk 375 instead of 315. Bill March, who tried a form of IC before the 1960 Olympics but abandoned it, failed to qualify before the last Olympic trials because he couldn't make the three-event lift minimum of 825 pounds. In March 1961 he resumed isometric contraction in earnest. Two months later he won the national junior weight lifting championship with 975 pounds, then a week later broke the North American record (32:20).

As a result of many studies such as Mathews and Krause concluded isometric type contractions resulted in greater strength gains than did the isotonic type (26:37). Isometric exercises spread to athletics. However, Bender explained that the great popular emphasis in isometric exercises was due either to commercialism or to an attempt to get on the publicity band wagon. Many persons have produced methods, gadgets and exercises to extol the huge benefits that can be derived from isometrics. Bender also stated that many of the methods used in isometrics were based on fantasy rather than facts (4:21).

The public relations pitch for isometrics has been prodigious. "Five minutes a day to keep fit," said Morris in the Farm Journal in January 1964. "How to move inches without moving an inch," said Mademoiselle in June of 1963 (19:58). Vic Obeck (6 feet, 220 pounds) carefully pointed out that isometrics did not directly affect endurance and stamina, nor did it cut weight, but IC did tone muscles (without increasing girth) at a startling rate. So convinced that this was something, Obeck taped a $3.98 LP for Riverside Records. Its title: "Isometric Exercise." Its paradoxical subtitle: "How to Exercise Without Moving a Muscle." Obeck promised that a daily five minute dose of IC will augment strength some five per cent a week (29:78). The cover on one paperback book proudly announces: "This is the isometric exercise program successfully proven in Olympic competition." Another booklet on this so-called "simple way to slim down and stay fit" lables isometrics as the "startling new form of exercise--a method now in use and proved by professional athletes, swimming and track stars, and combat marines (19:58)." Still another article "Six seconds for Exercise" say we can still get all the exercise we need and keep ourselves in top trim by using odd moments during the day--those free seconds spent waiting or at a traffic light, telephoning or standing in line. It quotes Jay Bender as saying "All you need do is use your muscles as you go

through a routine day at home or office." The nine basic exercises are recommended (27:57).

As a result of commercialism, Charles Atlas, now 74, still sells his own system in seven languages to over 70,000 converts each year for $30 per thirteen week course. He keeps in trim by tensing his massive muscles, even on the way to the bank (2:47).

> As a gimmick for stimulating interest they have real value. As a fad for the public they are respectable. As an exercise in weightless space they are commendable. To the purveyors of special mechanical gadgets they are profitable, but for professional physical educators to sell out to them as a cure-all would be inexcusable (37:22)."

Recent research indicates that unless you contract your muscle at least two-thirds or more of that muscle's strength, you are not going to reach the so-called benefits of five per cent gain in strength per week. Moreover, the original claims of Hettinger and Muller of five per cent strength per week seem in light of research to be exaggerated. "No other study has varified such strength gains," says H. Harrison Clark of the University of Oregon. "A more realistic figure might be two per cent per week and even that may be generous (19:66)." Subsequently Hettinger found only 3.3 and 1.8 per cent increase per week in 1958 and 1961 (33:215). Arther H. Steinhaus indicated that while initial gains appear large, further gains level out--like a stairway with progressively lower steps the higher you go. "You can't get

maximum growth with just one contraction a day," says Steinhaus. "It has to be five to ten contractions. So today the repetitions of the weightlifters are back in order." Physiologists also criticize the idea that general body strength can be built by a few isometric contractions. Jay Bender says this is a falsehood. "Isometrics are very specific. You exercise one muscle at a time. Now if you only have one weakness, it's quick and easy because there is probably only one muscle area you have to bother with; but if you are interested in general conditioning, it is as time consuming as anything else. Because isometrics are so specific you have to work all parts of the body to make sure you're getting the whole area (19:66).

Steinhaus points to some IC limitations however, "It does nothing for the heart or lungs and it does not increase endurance. It is strictly a system for increasing strength, and strength is only one aspect of fitness." Karpovich says, "There are more claims than evidence. Isometric contraction will not build endurance and stamina (32:21)."

Several dangers exist in the use of isometrics. A person seeking to cure an injury runs the risk of developing the wrong muscles while the injured muscle grows weaker, thus multiplying the chances of further injury. Persons with

cardiac conditions should by-pass isometrics. A properly executed isometric contraction is probably the most vigorous exercise you can do in terms of strain. It develops tremendous amounts of pressure in the cardiovascular system causing sudden change in blood pressure (19:68-69).

Despite its limitations, a very definite place for isometrics does exist. One such place is in therapeutics, especially involving people in limb casts.

Isometric exercise will not, of course, do the whole job if its a big and neglected job. They will not help a non-dieter lose weight, but they will take inches off and increase strength. Walsh recommends six seconds per contraction and three sets (27:34-38). Isometrics have a value as supplement exercise in a training regime that also includes isotonic exercises and running or walking (19:69). Rogin says, "It's a valuable supplement but not a substitute (32:21)."

III. A COMPARISON OF ISOTONIC STUDIES TO ISOMETRIC STUDIES

Since the introduction of isometric contraction theory of exercise for muscular strength development and jumping ability, there has been much controversy over its value. Many research studies have been done comparing the

effects of isometric exercise to those involving weight training exercises in the development of strength. Some of the studies indicate that isometric exercise was more valuable, others indicate that weight training is more valuable, and still others show no difference between the value of the two.

The author will now review such existing literature hoping to shed some additional light on the subject.

Strength

Kintisch contends just because a boy is big, many coaches are too ready to assume he must be strong. This doesn't always follow (24:7). A muscle will perform a task it is assigned, if the task is within reason (21:19). What about the reserve athlete who is too weak to perform the elementary movements? Should he always be defeated because he is too weak to compete in basketball skills of rebounding, shooting, passing and etc.? Obviously the answer is no. Through a well-prepared training program of exercise, either isometric or isotonic, strength may be developed.

In training for strength, muscles increase in size because strength depends on the cross section of muscle fiber. Although the size of muscle increases through resistance exercise the number of fibers stays the same (22:119).

Weight training is an excellent activity for off-season workouts which contribute to the maintenance of physical condition. Without off-season workouts much of the time during the early season, which could be spent profitably on fundamentals or other aspects of the game, must be spent on activities designed to provide adequate physical training. Weight training, when accompanied by some running, will adequately solve the problem of off-season exercise. Merely pursuing an exercise program off season is not enough for all players. Weight training will, however, improve some of the physical qualities of a player, and in this way contribute to his overall playing ability. During the regular season it is reasonable to permit certain individuals to participate in a modified weight training program, designed to meet specific needs. Such workouts should consist of two periods per week. The coach should carefully watch for signs of fatigue (36:28-31).

Physical educators should try to bring success to all boys not just develop outstanding individuals. Isometric and isotonic training programs are tools which serve a specific purpose and are not to be construed as a complete physical education or athletic program.

Isometric vs Isotonic

Considerable research has been carried out on the efficiency of isotonic and isometric programs for the purpose of developing muscular strength and jumping ability.

In this study no attempt was made to compare the dynamometer test with the vertical jump. Smith supports the hypothesis that strength exerted against a dynamometer involves different neuromotor patterns than strength by the muscles during movement (35:405). Smith's data supports the Henry and Whitley hypothesis that the two types of muscular action are controlled by different neuromotor patterns (35:406).

It has been a known fact for many years that isotonic exercise produces increased speed, power, jumping ability, and strength (14:192-193) (12:90-93) (38:46) (36:64-67). Due to the findings of Hettinger and Muller, however, interest has recently been engendered in various forms of static (isometric) exercise and its effect upon muscular strength (18:348) (41:450) (5:36). Recent research shows disagreement as to the better method of exercise. Mathews (26:37) found greater strength gains in the isometric group when studying the elbow flexor muscle groups. Berger (7:131-134) concluded isometric exercise more beneficial than isotonic while working with the bench press. However, Berger (8:423) found later that dynamile overload training

is more effective for increasing vertical jumping ability than is static overload training. Also, a significant increase in static strength does not guarantee an improvement in vertical jumping ability. Berger (11:145) found dynamic strength more superior in leg power than static strength, in a cable tension strength test. Berger (11:144) stated that Joe E. Henderson in an unpublished thesis related leg power to dynamic leg strength and obtained coefficients of .64 and .71, respectively, which were not significantly different from each other. Several other studies related no difference between strength gains of the two different methods. Berger (10:13) found by testing on the dynamometer that neither dynamic leg strength nor static leg strength is more related to leg power than the other. Dennison (18:351) substatuated this in the upper arm. Chui (15:252) found no difference, strength gained or in speed of movement, between the two methods.

In conclusion, the evidence read and summarized by the author points to one question. Could controlled dynamic movement against resistance be essentially a successive series of isometric contractions of individual motor units at distinct points through a given range of motion about a joint (6:8)? If this were true it would be impossible to have isotonic contraction without isometric contraction.

This research indicated that isometric and isotonic exercises were essentially the same in producing strength increases. The tension recorded in a single maximum isometric contraction was not much different than the weight that could be handled in a single maximum isotonic contraction. Some of the studies show isometric exercise resulted in greater strength gains. Other studies reveal isotonic produced greater increases, and other sutdies showed no significant differences. The author inthe following chapters will try to determine which is the better for increasing strength and jumping ability.

CHAPTER IV

ANALYSIS OF DATA

The subjects of the isometric, isotonic, and the control groups were compared by gain or loss in mean scores.

The mean scores of all tests were calculated by equations found in table V of the appendix.

Table I indicates the leg strength differences, mean gain, and the Fisher t between the three groups. The mean score relationships were checked at the .05 and .01 levels of confidence with 78 degrees of freedom.

Leg strength mean, gains, and t's within each group are found under Table II in the appendix. In establishing the results the .05 and .01 levels of confidence were used with 39 degrees of freedom.

The results of mean gain, differences, and t's for the Sargent Jump between groups are found under table III. The scores were tested at the .05 and .01 levels of confidence with 78 degrees of freedom.

Table IV shows the Sargent Jump mean, gains, and t's within each group. Their relationships were checked at the .05 and .01 levels of confidence with 39 degrees of freedom.

The mean scores of all tests were computed to show if there were sufficient differences in the three groups. No matter how often other similarly selected samples are

compared, the same level of confidence will persist. Also, it is important to know how nearly the differences are to approaching significance. The statistical means of achieving these comparisons is to formulate a t relationship between control and experimental tests and also the t improvement within each group.

Leg Strength

The control group had a mean score of 756.00 on their pre-test of leg strength. The isometric experimental group had a pre-test leg strength mean score of 689.75. The isotonic experimental group obtained a pre-test mean score of 690.75. When comparing the pre-test results of the control, 756.00, and the isometric experimental group, 689.75, this shows a difference of 66.25, and results in a t of 1.495 which is not significant at the .05 level of confidence. The control pre-test results, 756.00, when compared to the isotonic, 690.75, shows a difference of 65.25 and a t of 1.341, which is not significant at the .05 level. The isometric experimental group had a mean score of 689.75 and the isotonic experimental group had 690.75 as a mean score. This shows a difference of 1.00 and a t of .0208, which is not significant.

Statistically the pre-test results indicate there is no difference between control and experimental groups.

The leg strength mean score of the control group was 1080.50 on the second test. The isometric experimental group had a mean score of 1032.00. This shows a mean difference of 48.50 and a t of .8902 which is not significant at the .05 level. When comparing the control, 1080.50, to the isotonic experimental group, 1061.25, shows a mean difference of 19.25 and a t of .3240 which is not significant at the .05 level. The second test result of the isometric experimental group, 1032.00, and the isotonic, 1061.25, shows a mean difference of 29.25 and a t of .0527 which is not significant at the .05 level.

The second mean scores of the three groups showed no significant differences between the groups.

The post-test results for the control group showed a mean score of 1188.50. When compared to the isometric experimental group, 1148.50, this gives a difference of 40.00 and a t of .8369. This shows no significant difference at the .05 level of confidence. The control, 1188.50, mean score compared to the isotonic mean score of 1135.75 shows a difference of 52.75 and a t of 1.2665 which is not significant at the .05 level. The post-test results of the isometric experimental group of 1148.50 when compared to the isotonic experimental group of 1135.75 shows a difference of 12.75 and a t of .2348 which is not significant at the .05 level.

The post-test results show no difference statistically between groups.

Analysis of these findings indicate that there is no significant difference statistically between the three groups at each test period. The author reasons that the control group exercises too closely resemble weight exercise, therefore no significant improvement was shown by the experimental groups.

Analysis of all data used at this point can be found in the appendix under table I.

Another comparison made by the author was that of the amount of growth made in each of the groups. In this comparison the mean scores of the pre-test control is compared with the mean scores of the second test and the post-control groups to determine, if any, the amount of gain.

The leg strength pre-test mean score for the control group was 756.00 and the second test mean score was 1080.50, for an increase of 324.50. This gives a t of 6.165 which is significant beyond the .01 level of confidence. The second test mean score of 1080.50, compared with the post-test mean score of 1188.50 shows an increase of 108.00 and is significant at the .05 level of confidence. The control pre-test mean score of 756.60 when compared with the post-test mean score of 1188.50 shows an increase of 432.50. This gives a t of 10.833 which is significant at the .01 level of confidence.

The isometric experimental pre-test mean score for leg strength was 689.75. The mean score on the second test was 1032.00, which is an increase of 342.25. The t obtained is 7.157 which is significant at the .01 level of confidence. The second mean test score of 1032.00 when compared to the post-test mean score of 1148.50 shows an increase of 116.50. This gives a t of 2.088 which is significant at the .05 level of confidence. The comparison of the pre-test, 689.75, to the post-test mean score, 1148.50, gives an increase of 458.75. This gives a t of 8.730 which is significant at the .01 level of confidence.

The leg strength pre-test mean score for the isotonic experimental group was 690.75. The second test was 1061.25, which is an increase of 370.50. This gives a t of 6.473 which is significant beyond the .01 level of confidence. The second test mean score of 1061.25 compared to the post-test score shows an increase of 74.50. This gives a t of 1.05 which is not significant. The pre-test mean score, 690.75, when compared to the post-test mean score, 1135.75, is an increase of 445.00. The t obtained is 8.707 which is significant at the .01 level of confidence.

The isotonic group made largest mean gain between the pre-test and the second test. The mean gain difference favored the isotonic group over the isometric by 28.25. This gives a t of .5201, which is not significant. Isotonic

experimental group was stronger than the control by 46.00. This gives a t of .7935 which is not significant. However, this does show that the isotonic group increased in strength more than either the control or the isometric group from the pre-test to the second test.

Between the second test and the post-test, the isometric group mean gain was the largest. The isometric experimental group mean gain was 116.50. The control mean gain was 108.00. This gives a difference of 8.50 and a t of .1972 which is not significant. The isotonic group mean gain was 74.50. The isometric mean gain was 116.50, which is a difference of 42.50 and a t of 1.1514 which is not significant.

The total mean gains from pre-test to post-test favors the isometric experimental group. The isometric mean gain was 458.75; the control group mean gain was 432.50. This is a difference of 26.25. This gives a t of .5375 which is not significant. The isometric experimental mean gain of 458.75 when compared to the isotonic experimental of 445.00 shows an increase of 13.75. The t obtained is .2521 which is not significant. All preceeding results may be found in the appendix under tables I and II.

Isotonic exercise method is the best for building leg strength gains in shorter periods of time.

Isometric exercises build leg strength the best over a nine week period.

However, two points must be realized: (1) results pertain only to the methods used in this thesis, and (2) statistically there is no difference between the three programs.

The following figures illustrate the above facts about leg lift tests:

LEG STRENGTH t AND MEAN DIFFERENCES

	Pre-Mean	Post Mean	Diff. of Mean	t	Level of Confidence
Isometric exp. group	689.75	1148.50	458.75	8.730	.01
Isotonic exp. group	690.75	1135.75	445.00	8.707	.01
Control group	756.00	1188.50	432.50	10.833	.01

Sargent Jump

The mean score of the pre-test control group on the Sargent Jump was 20.315. The mean score of the isometric experimental group was 20.406, a mean difference of .091. This results in a 5 of .1491, which is not significant at the .05 level of confidence.

The mean score of the control group, 20.315, compared with the mean score of the isotonic experimental group, 19.846, shows a mean difference of .469 and results in a t

of .7151. The t obtained was not significant at the .05 level of confidence. The isometric pre-test mean score, 20.406, compared to the isotonic mean score of 19.846 results in a mean difference of .560. The t obtained was .7979, which is not significant at the .05 level of confidence.

The pre-test results show there was no appreciative difference between the three groups at the beginning of the experimentation.

The second test mean score of the control group on the Sargent Jump was 21.084. The mean score of the isometric experimental group was 22.209, a mean difference of 1.206. This results in a t of 1.965, which is not significant at the .05 level of confidence.

The mean score of the isotonic experimental group, 21.371, shows a mean difference of .287, and results in a t of .4287. The t obtained was not significant at the .05 level of confidence.

The isometric mean score, 22.290, compared to the isotonic mean score of 21.371 results in a mean difference of .919. The t obtained was 1.2569, which is not significant at the .05 level of confidence.

The mean scores indicate that after the second test there is no statistical difference between the three groups.

The mean score on the post-test of the control group was 21.956. The mean score on the post-test of the isometric experimental group was 22.612, which shows a difference of .656. The t obtained was 1.102, which is not a significant gain at the .05 level of confidence. The mean score of the control group, 21.956, compared with the mean score of the isotonic experimental group, 22.475, shows a mean difference of .519 and results in a t of .8370. The t obtained was not significant at the .05 level of confidence. The isometric post-test mean score, 22.612, compared to the isotonic mean score of 22.475, results in a mean difference of .137. The t obtained was .203, which is not significant at the .05 level of confidence.

The results of these comparisons again show no appreciative difference between groups.

The next comparison will show the growth within the control and experimental groups.

The Sargent Jump pre-test mean score for the control group was 20.315. The second test mean score was 21.084, which is an increase of .769. The t obtained was 1.386, which is not significant at the .05 level of confidence. The second test mean score of 21.084, compared with the post-test mean score of 21.956, shows an increase of .872. The t obtained was 1.609, which is not significant. The pre-test mean score, 20.315, compared to the post-test, 21.956,

shows an increase of 1.641. This results in a t of 2.989, which is significant at the .01 level of confidence.

The Sargent Jump pre-test mean score for the isometric experimental group was 20.406. The second test mean score was 22.290, which is an increase of 1.884. The t obtained was 2.785, which is significant at the .01 level of confidence. The second test mean score of 22.290, compared with the post-test mean score of 22.612 shows an increase of .322. The t obtained was .476, which is not significant. The pre-test score, 20.406, compared to the post-test, 22.612, shows an increase of 2.206. This results in a t of 3.322, which is significant at the .01 level of confidence.

The Sargent Jump pre-test mean score for the isotonic experimental group was 19.846. The second test score was 21.371. This shows an increase of 1.525 and a t of 1.978 which is not significant. The second test mean score, 21.371, compared to the post-test, 22.475, shows an increase of 1.104. The t obtained was 1.472, which is not significant. A comparison of the pre-test mean score, 19.846, with the post-test mean score, 22.475, shows an increase of 2.629. The t obtained was 3.598, which is significant at the .01 level of confidence. All facts used on the Sargent Jump up to this point can be found in the appendix under table III.

The isometric experimental group made the largest gain in jumping ability between the pre-test and the second

test. The isometric pre-test to second test increased 1.884, compared to the control, .769, this is a mean gain difference of 1.115. The t obtained is 4.686, which is significant at the .01 level of confidence. The isometric pre-test to second test increased 1.884, compared to the isotonic experimental groups increase of 1.525. This is a difference of .359, which results in a t of 1.107. The t is not significant at the .05 level of confidence.

The isotonic experimental group gained more in jumping ability from the second test to the post-test. The isotonic increased 1.104 compared to the control group's .872. This is a difference of .232, which results in a t of 1.057. The t is not significant. The isotonic experimental group increased 1.104 and the isometric experimental group increased .322. This is an increase in mean difference of .782, which results in a t of 3.432. The t is significant at the .01 level of confidence.

The largest overall mean gains in jumping ability were made by the isotonic experimental group. From the pre-test to the post-test the isotonic experimental group had a mean gain of 2.629. The control had a mean gain of 1.641 which is a difference of .988. The t obtained is 3.359, which is significant at the .01 level of confidence.

The isometric experimental group had a total mean gain of 2.206 compared with the isotonic experimental group's

total mean gain of 2.629. This is a difference of .422, and the t obtained is 1.507. The t is not significant at the .05 level of confidence.

The following figures illustrate the above facts:

SARGENT JUMP t AND MEAN DIFFERENCES

	Pre-Mean	Post Mean	Diff. of Mean	t	Level of Confidence
Control	20.315	21.956	1.641	2.989	.01
Isometric exp. group	20.406	22.612	2.206	3.322	.01
Isotonic exp. group	19.846	22.475	2.629	3.598	.01

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at Davis High School, Yakima, Washington, utilizing one hundred and twenty fifteen-year-old sophomores enrolled in the physical education classes. The subjects were divided into three groups; a control group and two experimental groups. The three groups were tested with the dynamometer for leg strength and the Sargent Jump for jumping improvement. The experimental groups participated in isometric and isotonic exercises three days a week and two days a week they played American football. The control group participated in regular physical education classes. The units covered during the nine week period were American football and gymnastics involving only the upper body. Following the pre-test the subjects were tested after a five week period and again after a nine week period. The results indicate no statistical difference between groups at any period in leg strength. However, the results were that both experimental groups showed a significant gain in the Sargent Jump.

All groups progressed and improved at the same statistical rate of speed in leg strength. The improvement, from the beginning to the conclusion of the testing period of the three groups, were significant at the .01 level of confidence.

The author concludes that all three methods are a good means of improving leg strength. The physical education exercises used by Davis High physical education program so nearly resemble weight training no significant difference existed between the three groups. It was also noted that the isotonic group was the strongest after the first five weeks. The control and isometric groups made the larger gains in the last four weeks. Reasoning from this evidence, it may be assumed that the isotonic group needed a larger overload. The isometric group improved the most in leg strength but it was not significant at the .05 level of confidence. Since no statistical difference in strength gains were found, this would support evidence found by Berger (10:13), Dennison (18:351), and Chui (15:351).

The results of the Sargent Jump show both experimental groups significantly better than the control group. The isometric was more significant than the control at the .05 level of confidence. The isotonic was greater at the .01 level of confidence. When comparing isometric with isotonic, the results show that up to five weeks isotonic gains more rapidly. The isotonic gains were at the .01 level of confidence. However, the post-test results show no significant difference.

Evidence seems to support, as found in chapter IV, that leg strength does not necessarily indicate jumping

ability. The control group was equal to both experimental groups in leg strength but was significantly different in jumping ability.

The author recommends that this study be carried on over a longer period of time.

It is also recommended that a re-evaluation of this study applying the overload principle to the isotonic exercises be conducted.

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APPENDIX

TABLE I

LEG STRENGTH MEAN DIFFERENCES AND FISHER t

Group	Pre-Test	2nd Test	Post	Mean Gains Pre-Post	Mean Gains 2nd Post	Mean Gains Pre-2nd
Isometric	689.75	1032.00	1148.50	458.75	116.50	342.25
Control	756.00	1080.50	1188.50	432.50	108.00	324.50
Mean Difference	66.25	48.50	40.00	26.25	8.50	17.25
Fisher t	1.495	.8902	.8369	.5375	.1972	.3513
Degree of Freedom	78	78	78	78	78	78
Isometric	689.75	1032.00	1148.50	458.75	116.50	342.25
Isotonic	690.75	1061.25	1135.75	445.00	74.50	370.50
Mean Difference	1.00	29.25	12.75	13.75	42.50	28.25
Fisher t	.0208	.5227	.2348	.2521	1.1514	.5201
Degree of Freedom	78	78	78	78	78	78
Control	756.00	1080.50	1188.50	432.50	108.00	324.50
Isotonic	690.75	1061.25	1135.75	445.00	74.50	370.50
Mean Difference	65.25	19.25	52.75	12.50	33.50	46.00
Fisher t	1.341	.3240	1.2665	.2629	.7733	.7935
Degree of Freedom	78	78	78	78	78	78

TABLE II

LEG STRENGTH MEAN GAIN AND FISHER t

Test	Isometric Group Mean	Control Group Mean	Isotonic Group Mean
Pre-Test	689.75	756.00	690.75
2nd Test	1032.00	1080.50	1061.25
Gain	342.25	324.50	370.50
Fisher t	7.157*	6.165*	6.473*
Degree of Freedom	39	39	39
2nd Test	1032.00	1080.50	1061.25
Post Test	1148.50	1188.50	1135.75
Gain	116.50	108.00	74.50
Fisher t	2.088**	2.263**	1.333
Degree of Freedom	39	39	39
Pre-Test	689.75	756.00	690.75
Post Test	1148.50	1188.50	1135.75
Gain	458.75	432.50	445.00
Fisher t	8.730*	10.833*	8.707*
Degree of Freedom	39	39	39

*Sign @ .01 Level
**Sign @ .05 Level

TABLE III

SARGENT JUMP MEAN DIFFERENCES AND FISHER t

Group	Pre-Test	2nd Test	Post	Mean Gains Pre-Post	Mean Gains 2nd Post	Mean Gains Pre-2nd
Isometric	20.406	22.290	22.612	2.206	.321	1.884
Control	20.315	21.084	21.956	1.640	.871	.769
Mean Difference	.091	1.206	0.656	.566	.550	1.115
Fisher t	.1491	1.925	1.102	2.245**	2.351**	4.686*
Degree of Freedom	78	78	78	78	78	78
Control	20.315	21.084	21.956	1.640	.871	.769
Isotonic	19.846	21.371	22.475	2.628	1.103	1.525
Mean Difference	.469	.287	.519	.988	.232	.756
Fisher t	.7151	.4287	.8370	3.359*	1.057	2.337**
Degree of Freedom	78	78	78	78	78	78
Isometric	20.406	22.290	22.612	2.206	.321	1.884
Isotonic	19.846	21.371	22.475	2.628	1.103	1.525
Mean Difference	.560	.919	.137	.422	.782	.359
Fisher t	.7979	1.2569	.2030	1.507	3.432*	1.107
Degree of Freedom	78	78	78	78	78	78

*Sign @ .01 level
**Sign @ .05 level

TABLE IV

SARGENT JUMP MEAN GAIN AND FISHER t

Test	Isometric Group Mean	Control Group Mean	Isotonic Group Mean
Pre-Test	20.406	20.315	19.846
2nd Test	22.290	21.084	21.371
Mean Gain	1.884	.769	1.525
Fisher t	2.785*	1.386	1.978
Degree of Freedom	39	39	39
2nd Test	22.290	21.084	21.371
Post Test	22.612	21.956	22.475
Mean Gain	.322	.872	1.104
Fisher t	.476	1.609	1.472
Degree of Freedom	39	39	39
Pre-Test	20.406	20.315	19.846
Post Test	22.612	21.956	22.475
Mean Gain	2.206	1.641	2.629
Fisher t	3.322*	2.989*	3.598*
Degree of Freedom	39	39	39

*Sign @ .01 Level
**Sign @ .05 Level

TABLE V

EQUATIONS USED IN ANALYSIS OF DATA

$$\text{Mean} = \frac{\Sigma X}{N}$$

$$\sigma = \sqrt{\frac{N}{\frac{\Sigma X^2}{N} - M^2}}$$

$$\sigma_M = \sqrt{\frac{\Sigma X^2}{N-1}}$$

$$\sigma_D = \sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2}$$

$$D_M = M_1 - M_2$$

$$t = \frac{DM}{\sigma_D}$$